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Review of Graphene Oxide for anti-bacterial and anti-viral functions

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Introduction

The recent Covid-19 pandemic as a global health crisis has triggered intense R&D to find vaccines, detection methods and personal protection. Research groups around the world are now focusing on providing products to confront COVID-19. Graphene based materials such as graphene oxide (GO) have been identified as a promising candidate in biomedical applications due to their unique properties such as biocompatibility, hydrophilicity, high surface area, dispersity as well as antibacterial/antiviral properties [1,2]. The interaction mechanism between graphene oxide and various pathogen leads to inhibit the bacterial and viral growth. Graphene oxide has high potential to help in the war on Covid-19 virus, by novel and cost-effective technologies with high efficiency being prepared for virus prevention. Recently, graphene oxide nanocomposites have also been used for anti-bacterial coatings [3], sensors [4], and other biomedical [5]. Antibacterial and antiviral coating with graphene oxide nanocomposites have great potential in health care to control microbial and viral infection. The combination of nanoparticles such as silver, titanium dioxide and magnetite nanoparticles with graphene oxide can be considered for personal protection equipment to decrease the transmission of viruses increases effective, increases surface area and prevent from the aggregation of graphene oxide nanosheets [6]. Graphene oxide nanocomposites can be used as face mask filter due to remarkable antibacterial/ antiviral properties for health protection. The biomedical application of graphene oxide nanocomposites is schematically illustrated in Fig. 1.

The development of graphene-based antibacterial materials to face current challenges to combat against the bacterial targets has been investigated. Antibacterial properties of graphene-based materials is illustrated in Table1 that combine the antibacterial properties of nanoparticles with the antibacterial property of graphene to achieve the enhanced effect [3].

Table 1. Antibacterial properties of graphene-based materials.

Graphene Materials	Bacteria Model	Evaluation Method	Inhibition
		Graphene family	
GO	*S. aureus/P. aeruginosa*	ADA	93.7/48%
GO	*P. aeruginosa*	Plate count	100%
rGO	*E. coli*	Plate count	88%
		Functionalized with Silver NPs	
GO-AgNPs	*E. coli/S. aureus*	Plate count	100%
GO-Ag_3PO_4 NPs	*E. coli/S. aureus*	Plate count	92.8/100%
rGO-AgNPs	*E. coli*	Plate count	100%
		Photocatalytic Functionalization	
rGO-TiO_2	*E. coli/S. Aureus*	ADA	N/A
rGO-ZnO	*E. coli*	Plate count	100%
GO-ZnO	*E. coli*	Plate count	100%
GO-CdS	*E. coli/B. subtilis*	Plate count	100%
		Functionalization with Other Metal Ions/Oxides	
rGO-Cu_2O	*E. coli/S. aureus*	Plate count	70/65%
GO-Fe_3O_4	*E. coli*	Plate count	91.5%
GO–Fe_2O_3	*E. coli*	Plate count	97%

GO/Ag nanocomposites can be considered for personal protection equipment to decrease the transmission of viruses. Fig. 2 shows anti-viral properties of Ag nanoparticle decorated graphene matrices [5].

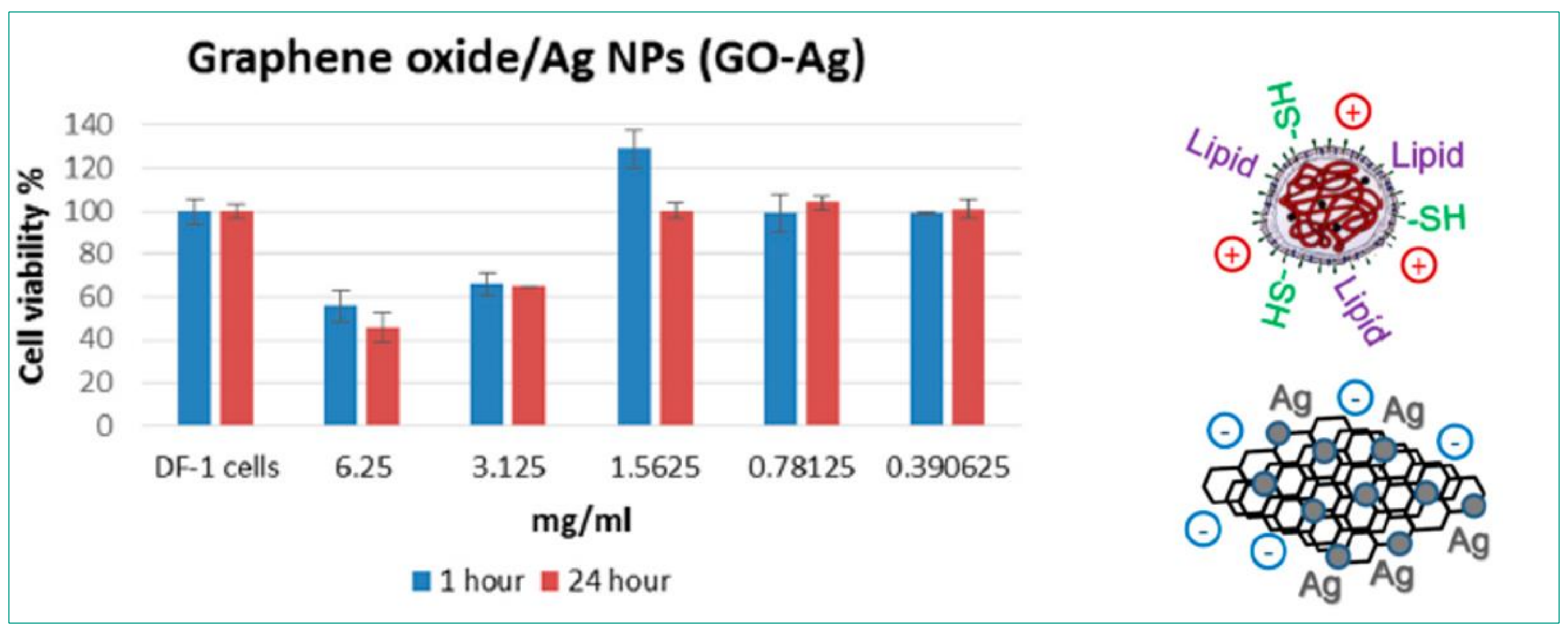
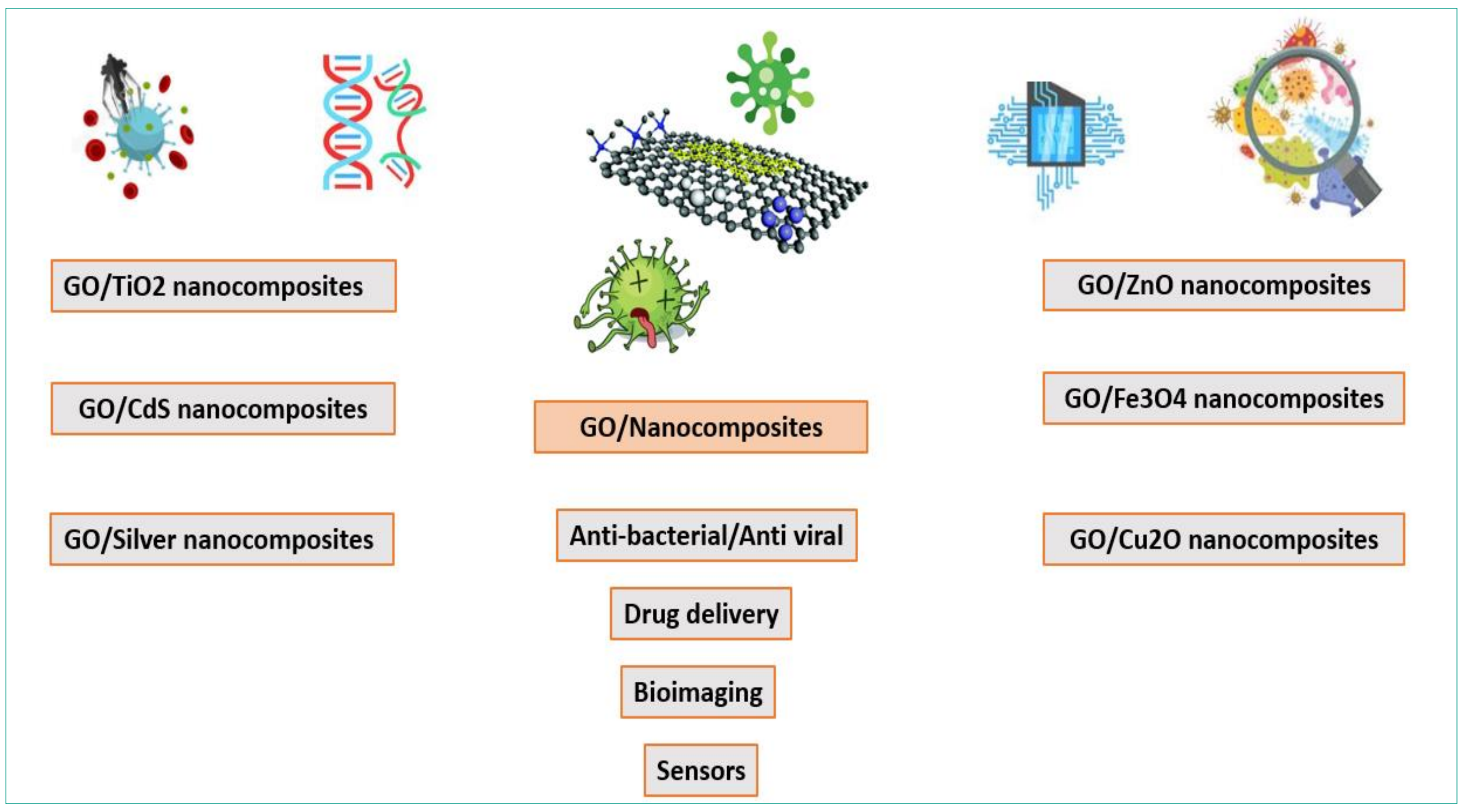


Figure 2. Anti-viral properties of Ag nanoparticle decorated graphene matrices [5].


GO/TiO2 nanocomposites

GO/CdS nanocomposites

GO/Silver nanocomposites

GO/Nanocomposites

Anti-bacterial/Anti viral

Drug delivery

Bioimaging

Sensors

GO/ZnO nanocomposites

GO/Fe3O4 nanocomposites

GO/Cu2O nanocomposites

Figure 1. Schematic of applications of graphene oxide nanocomposites for anti-bacterial /anti-viral

Graphene-based material has contributed to the fabrication of sensitive sensors and biosensors due to its physical and electrochemical properties. Table 2 indicates graphene-based sensors performance for the detection of toxic gases [4]

Table 2. Graphene-based sensors performance for the detection of toxic gases [4].

Material	Target Gas	Sensitivity	LOD	Response Time	Year
rGO-ZnO	NO_2	$\Delta R/R_0 = 25.6\%$	5 ppm	165 s	2014
CuO-ZnO/rGO	acetone	$R_g/R_a = 1.5$	10 ppm		2014
Ni-doped SnO_2/GO	acetone	$\Delta G/G_0 = 27.5\%$	200 ppm	5.4 s	2015
GO-SnO_2	ethanol	$R_a/R_t = 160$	200 ppm	–	2017
	acetone	$R_a/R_t = 200$			
	formaldehyde	$R_a/R_t = 91$			
AgNPs-rGO	NH_3	$\Delta R/R_0 = 6.52\%$	1 ppm	70 s	2017
PtNPs-rGO		$\Delta R/R_0 = 2.87\%$		80 s	
AuNPs-rGO		$\Delta R/R_0 = 0.5\%$		100 s	
ZnO NW-rGO	NH_3	$\Delta R/R_0 = 19.2\%$	50 ppm	100 s	2017
ZnO-rGO	chloroform vapor	$\Delta R/R_0 = 1.75\%$	20 ppm	10 s	2017
TiO_2-rGO	NH_3	$\Delta R/R_0 = 1.7$	10 ppm	114 s	2017

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